Summary of the Argument

The Examiner rejected the claims of the present invention as being obvious in view of Jones, Tomita and Cole. Jones is cited because it discloses a single phase pelletized product that is formed by dropping a premix into a cryogen liquid. Jones does not disclose the specific composition of its ice cream formulation. Jones merely states that it is like a free flowing frozen alimentary dairy product. In view of the deficiencies of Jones teaching concerning the composition of his frozen dairy product the Examiner cites Tomita and Jones.

Applicants product is a frozen dessert product comprising a single phase product consisting essentially of premix. The pellet results from the premix being introduced into a cryogen as a small individual volume of liquid thereby freezing the pellet. The pellet remains a solid phase product at temperatures of from -25°C to -5°C without fusing to an adjacent pellet stored there with.

Applicant's invention differs from Jones because the Jones product is incapable of being stored at a temperature warmer than -29°C. We direct your attention to column 2 lines 51-65 of Jones where Jones states:

> "The large beads, between approximately 10 mm and 2 mm in diameter, recovered following the sifting step are placed within a container. This container is maintained open for a sufficient period of time, such as, for example, 1 to 10 minutes, to allow any residual refrigerant retained in or on the beads during freezing to vaporize. Following this, the container is sealed for storage. The container is then placed in a freezer. The temperature within the freezer is maintained at least as low as -20.degree. F. [- 29°C] and, preferably, between -30.degree. and -40.degree. F.[-34.4° – 40°C], if the product is to be stored for periods of greater than approximately 30 hours. This is necessary to ensure that the individual beads remain free-flowing and that no large ice crystals are formed during thaw/refrigeration cycles."

The storage temperature of the Jones product is so cold the product cannot be served to consumers unless it is heat up prior to serving Jones States at column 2 lines 66 - column 3 lines 1-12.

> "Prior to serving the product for consumption, it is necessary to bring the beads to a temperature -20 degree. F-[- 29°C] or above. If this is not done, the beads are too cold for some individuals to enjoy. More preferably, one method of serving the product includes a step of maintaining the beads at a temperature of substantially -15 degree. F. [-26.1°C] for no longer than approximately 30 hours prior to serving. If maintained at this or a warmer temperature for a longer period of time, the beads become tacky and begin sticking together. Thus, the unique free-flowing characteristic is lost and with it, some of the consumer appeal as well. As such, storage at a temperature of -15 degree. F. for longer than 30 hours, is to be avoided. For certain compositions, however, it should be recognized that the critical time may be as short as ten to twelve hours."

Applicants product does not suffer from the deficiencies of Jones because Applicant's product can be stored at temperatures that range from -25°C to -5° and does not suffer from the agglomeration problem of Jones.

The patents to Tomita and Cole do not overcome the problem of Jones. Both patents relate to soft serve ice cream or bulk scoop product and not products to be stored at Jones extremely cold temperatures. At such temperatures neither Cole nor Tomita's product would be soft or scoopable. Tomita and Cole are also not pertinent for additional important reasons.

First neither product consists essentially of premix. Both products require significant amounts of air to be added to the mix to make their described product. Because air is present in Tomita and Cole neither product forms a single phase product when frozen as required by Applicant's claims.

Tomita U.S. Patent No 5,403,611

The presence of air in Tomita is critical to the teachings of that patent. The inventors extensively describe the need to add air to the ice cream mix to produce their desired product. The following is just a sample of the discussion in Tomita about the need to add air to the mix:

Column 1 Line 1: "The present invention relates to an ice cream having a property of excellent meltdown in the mouth, containing air cells with relatively large diameters uniformly, and a process for producing the same."

Column 1 Line 54: "by incorporating air into a continuous freezer to give an overrun of 10 to 150 % filling a container with the resultant mixture, and then hardening it."

Column 3 Line 36: "There is another method of giving property of excellent softness to an ice cream incorporating air into an ice cream mix to give an overrun."

Column 6 Line 35: "The constitutions of the inventions 1-2 of the present invention for accomplishing the above described objects comprise the following technical means (1) - (2): (1) An ice cream having a property of excellent meltdown in the mouth, a fat content of 5to 18% by weight and an overrun of 10to 150% by weight, containing air cell of 60 um or more in diameter at a ratio of at least 80% of total air cells."

Column 7 Line 43: "2) A process for producing an ice cream having a property of excellent meltdown in the mouth, which comprises incorporating air into an ice cream mix, which contains 5 to 18% by weight of fat, in a first cylinder of a freezer at a temperature of -3.0.degree. to -6.0.degree. C. to give an overrun of 10 to 20% by weight or less, then incorporating air into the said mix in a second cylinder of a freezer at a temperature of -3.0.degree. to -8.0.degree. C. to give an overrun of 10 to 150% by weight."

Column 6 Line 46: "A process for producing an ice cream having a property of excellent softness even at a freezing temperature, which comprises incorporating air into an ice cream mix in a first cylinder of the cylinders of two linked continuous freezers to give an overrun, transferring the said mix to a second cylinder at a specific temperature, and then mixing and kneading the said mix in the second cylinder without giving any additional overrun."

<u>Column 6 Line 65:</u> "The process for producing an ice cream having a property of excellent softness even at a freezing temperature according to the said (3), which comprises incorporating air into an ice cream mix in a first cylinder of the cylinders of two linked continuous freezers to give an overrun of 150% by weight or less, transferring said mix to a second cylinder at a temperature of -4.degree. to -8.degree. C., and then mixing and kneading the said mix in the second cylinder without giving any additional overrun."

<u>Column 7 Line 12:</u> "Thus, the process for producing an ice cream having a property of excellent softness even at a freezing temperature of the present invention is characterized by incorporating air into an ice cream mix in a first cylinder of the cylinders of two linked continuous freezers to give an overrun, transferring the said mix to a second cylinder at a specific temperature, and then mixing and kneading the said mix in the second cylinder without giving any additional overrun,"

<u>Column 8 Line 10:</u> "Further, the present invention relates to processes for producing an ice cream having a property of excellent softness even at a freezing temperature, which is characterized by incorporating air into an ice cream mix in a first cylinder of the cylinders of two linked continuous freezers to give an overrun,"

In the detailed description of the Invention, column 9 lines 41- 58, Tomita describes the importance of the large size of the air cells to the invention as follows:

> "The process for producing an ice cream having a property of excellent meltdown in the mouth of the present invention comprises incorporating air into an ice cream mix in a first cylinder of a freezer at a temperature of -3.0.degree. to -6.0.degree. C. (preferably -4.5.degree. to -6.0.degree. C.) to give an overrun of 20% by weight or less (preferably 0 to 10% by weight), then incorporating air into the said mix in a second cylinder of a freezer at a temperature of -3.0.degree. to -8.0.degree. C. (preferably -5.0.degree. to -8.0.degree. C.) to give an overrun of 150% by weight or less (preferably 20 to 120% by weight). According to this 2-step freezing method, an ice cream containing air cells of 60 .mu.m or more in diameter at a ratio of at least 80%, preferably at least 90%, of the total air cells is obtained. Since the obtained an ice cream contains no minute air cells, the occurrence of aggregates of fat is limited, and an ice cream having a property of excellent meltdown in the mouth can be obtained."

To eliminate air from the Tomita composition would destroy that invention for its intended purpose. Applicant's composition consists essentially of premix, no air is added

to the premix. Thus applicant's premix forms a single phase product where Tomita can not.

Cole U.S. Patent No. 4,374,154

The Cole patent cited by the Examiner does not overcome the deficiencies of either Jones or Tomita. Cole like Tomita require air to be present in the mix therefore can not be deemed a single phase product. Cole is directed to soft ice cream that is dispensed from a tooth paste-like tube or an extruder. In order to be capable of extruding the product from a tube or other dispenser the mix is required to have air or an inert gas injected into the mix. We direct the Examiner's attention to Column 4 line 45 where the inventor states:

> "The mix is then aged at a temperature of about 40.degree. F. (4.4.degree. C.) for from 4 to 24 hours and then passed through an ice cream freezer where air or an inert gas is incorporated into the product which is cooled and extruded at sub-freezing temperatures of about 20.degree. F. (-6.7.degree. C.) and thereafter stored in a hardening room at about -15.degree. F. (-26.1.degree. C.) or below."

The product is then whipped. Cole states at Column 4 Line 52:

"The product can be whipped to any desirable overrun but usually will be within the range of 100-200%, preferably about 110-150%."

Dictionary.com defines "whipped" inter-alia, as to beat (eggs, cream, etc.) to a froth with an eggbeater, fork or other implement in order to mix-in-air and cause expansion. Because air must be incorporated in the Cole product it can not be deemed a single phase product as required by applicant's claims.

ARGUMENT

Abstract Objections

The Examiner objected to the abstract of the disclosure because it is greater than 1 paragraph. Applicant has amended the abstract to be a single paragraph.

Claim Rejections – 35 U.S.C. § 112

The Examiner objected to claims 57 and 81-84 under 35 U.S.C. Section 112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention. Applicant respectfully submits that the term sucrose equivalency is well known in the art of ice cream making. The examiner's attention is directed to ICE CREAM, by Marshall, Goff and Hartel which is a leading book on the making of ice cream. Sucrose equivalency is defined as the equivalent content of sucrose in an ice cream mix based on all the mono- and di-saccharides that are present in the mix. See page 140 paragraph 3. Nonfat fat milk solids, whey solids, sucrose or other disaccharides, dextrose, high fructose corn syrup, and pure fructose are a few substances which are considered when determining sucrose equivalency. See page 140 paragraph 3.

Claim Rejections - 35 U.S.C. § 103

Summary of the Argument Detailed Discussion

Before getting into the specifics of the prior art rejection, Applicants would like to provide the Examiner with background information surrounding the present invention.

The present invention is directed towards a pelletized single phase frozen dessert made from a unique formulation that forms a pellet of a frozen dessert that retains its individual nature and doesn't agglomerate at commercial ice storage temperatures of

-20°C to -25 °C. Currently, a number of pelletized frozen dessert products are known in the art and are commercially available. One of the best-known pelletized frozen dessert products currently available are "DIPPIN' DOTS®" (which is the subject of U.S. Patent No. 5,126,156 (to Jones)). DIPPIN' DOTS® are made by introducing a conventional three phase type ice cream premix that is different from the claimed composition into a body of liquid cryogen, which causes the premix to rapidly freeze. See col. 5 lines 15-23.

Conventional bulk ice cream is distinct from a single pelletized frozen dessert product in both composition and method of creation. Marshall explains in ICE CREAM that conventional bulk ice cream is made in a two step process. See page 171 paragraph 1. First is the dynamic freezing step, in which the ice cream mix is partially frozen while being agitated to incorporate air and to limit the size of the ice crystals. See page 171 paragraph 1. Cold flavored ice cream mix enters the cylindrical freezer barrel, whipped with a dasher, and chilled with a liquid refrigerant. See page 171 paragraph 4. As the dasher whips the mix, only the portion of the mix that is in contact with the walls of the freezer barrel begin to freeze. See page 174 paragraph 2. As more of the mix freezes, the freezing point of the mix that remains in a liquid form lowers to a point where no more ice can be formed. See page 175 paragraph 1- page 176 paragraph 4. Thus, the water in traditional ice cream mix can never be completely frozen. Therefore traditional ice cream is not a single phased product since is has an air portion, liquid water portion, and a frozen or solid product portion.

As the premix is whipped with a dasher, air cells are incorporated into the ice cream. See page 180 paragraph 5. Marshall explains that when making traditional ice cream water and air are important. See page 37 paragraph 2. The primary purpose of the

incorporation of air cells is to create overrun, which is the increase in volume of the ice cream over the volume of the mix used. See page 37 paragraph 3.

As the premix is whipped and air is incorporated into the ice cream, the destabilization of the fat emulsion occurs. As the dasher whips the mix, the numerous small fat globules are destabilized and migrate toward the air cells and provide structure to the unfrozen phase of the mix. See page 179 paragraph 1- page 180 paragraph 4. Marshall also explains that this migration of fat globules to the air cells facilitates dryness upon extrusion, smooth eating texture, and resistance to meltdown. See page 43 paragraph 1 - page 44 paragraph 4. Thus, the method used to make bulk ice cream is significantly distinct from the method used to make pelletized frozen desserts because conventional bulk ice cream requires the fat globules in the premix to be destabilized for the ice cream to maintain its shape. Pelletized frozen desserts completely freezes in one step without the need to destabilize the fat globules. See paragraph 0023.

Once the method for creating bulk ice cream is complete, the final product is a mixture of solid (ice), liquid (water), and gas (air) which is a three phased product. See paragraph 0013. The three phase structure of bulk ice cream is distinct from the single phase of pelletized frozen dessert, which is only in a solid state. See paragraph 0037.

The Jones Dippin Dots product uses a conventional ice cream mix i.e. a mix that is used to make a three phased product. When the Dippin dots product is made however, because it uses a conventional mix the end product must be stored at significantly colder temperatures than are presently commercially available freezers. If the Dippin Dots produced is not kept at these significantly colder temperatures agglomeration of the pellets occurs.

Claims 34-39, 41, 43-51, 53, 55-66, 69-80, 83, and 84 are rejected under 35 U.S.C. Section 103(a) as being unpatentable over Jones (U.S. Patent No. 5,126,156) in view of Tomita et al. (U.S. Patent No. 5,403,611), and Cole (U.S. Patent No. 4,374,154). Applicant has amended independent claims 34, 46, 58, 80-84 to better reflect the distinctions between the present invention and the prior art. For example, claim 34 now covers a single phase pellet consisting essentially of a premix by introducing a small individual volume of liquid comprising 0.025% to about 0.075% artificial sweetener and a 6% to 7.5% sugar content into a cryogen. Neither Jones, Tomita, nor Cole or the combination thereof teach or suggest a single phase dessert product consisting essentially of a premix which is formed from a premix comprising 0.025% to about 0.075% artificial sweetener remaining in a single phase at a temperature of from about -25°C to about -5°C without fusing to another pellet.

Jones teaches a method for forming a pelletized dessert product comprising introducing a conventional bulk ice cream premix into a body of liquid cryogen. See col. 2 lines 16-29. The pelletized dessert product of Jones must to be stored at a temperature of about -29°C or colder. See col. 2 lines 57 to col. 3 line 12. Jones explains that if the dessert is going to be served in less than 30 hours, it may be stored at a temperature of -26°C. See col. 3 lines 1-4. The present application is directed towards a frozen dessert pellet that can remain at a single phase product at a temperature of from about -25°C to about -5°C without fusing to another pellet. See claim 34.

It is well known that commercial freezers and residential freezers operate at different temperatures. Commercial ice cream freezer trucks temperatures range from

about -20 to -26 degrees Celsius. While a home freezer system temperature ranges between -10 to -6 degrees Celsius. See paragraph 0078.

Applicant respectfully submits that an ice cream dessert which maintains a single phase through a temperature range of -25 to -5 degrees Celsius would not be obvious in light of Jones because applicant's invention maintains a single phase without fusing in the colder temperatures of commercial freezers and the warmer temperatures of home freezers, while Jones cannot. Jones explicitly teaches against storing his ice cream at temperatures of -26°C or warmer if it is not going to be consumed for 30 hours. See col. 3 lines 9-12.

Jones's requirement that the product be consumed within 30 hours in order to store it at a temperature of -26°C is not commercially feasible. Marshall teaches in ICE CREAM that ice cream generally spends typically 2 weeks in the warehouse freezer at the manufacturing plant, 4 weeks in the freezer at a distribution center, and sometimes 4 weeks at a retail outlet before it is sold for consumption. See page 249 paragraph 3. That is nowhere near 30 hours. Thus applicant respectfully submits that Jones's disclosure does not encompass the claimed invention because the amount of time associated with manufacturing, storing, and selling ice cream make practicing Jones's disclosure at temperatures of -26°C impractical. Jones is also incompatible with any refrigerated trucks or conventional trucks or storage freezers that operates at a temperature warmer than -29°C, whereas the present applicant is not.

Further, nowhere does Jones teach, suggest or disclose a premix which contains an artificial sweetener which would allow a frozen dessert to maintain a single phase

without fusing at temperatures of about -5°C to -10°C, or -18°C to -20°C, or -15°C to -18°C, or -25°C to -5°C as set forth in applicant's dependent claims.

The deficiencies of Jones are not cured by Tomita. First, Tomita is a conventional ice cream product and does not disclose or suggest a single phase pelletized dessert product nor a method of using cryogen to produce such a product. Instead, Tomita is directed to a process for producing an ice cream having the property of excellent meltdown in the mouth. See col. 6 lines 43-45. Tomita's disclosure contains a thorough discussion of ice cream classification. See col. 1 lines 46-68 to col. 2. lines 1-48. Tomita specifically points out that one quality which separates one type of ice cream from another is the amount of air. See col. 2 lines 40-45. Tomita is expressly directed towards an ice cream that contains air. See col. 6 lines 56-59. The present application is directed towards an ice cream product which does not contain air.

Tomita is further distinct from the present application because of the structural differences between the pellet product of the present application and Tomita's disclosure of bulk ice cream. The pellet dessert product claimed in the present invention is a single solid phase. The specification explains that the term single phase encompasses a homogeneously frozen solid in which the pre-mixed fluids are frozen very rapidly in a cryogen in small volumes and hence remain in the same homogeneous state as they were in the liquid pre-mix. See paragraph 0086. Tomita's disclosure is directed towards conventional bulk ice cream, which results in a product which co-exists in a liquid, solid, and gaseous state. See paragraph 0056. Applicant's pellet is also a much denser product for consumption. See paragraph 0045. Furthermore, as disclosed in the present application, because of the lack of air incorporated within each pellet of the present

invention, the frozen product of each pellet is 100% premix. See paragraph 0030. Tomita does not consist essentially of a premix because Tomita requires air to be added to the premix. Tomita teaches away from not adding air to the pre-mix.

By using "consisting essentially of premix", Applicants claims exclude air from being added to the premix. The lack of air in applicant's pellets is also significant because Tomita's disclosure is expressly teaches a processes for producing an ice cream which is characterized by incorporating "air into an ice cream mix". See col. 6 lines 56-59. The requirement of air in Tomita's disclosure distinguishes it from the claims of the present application because do not add air to the premix.

The Tomita disclosure describes a purified sugar content range of 8-20%. See col. 1 line 53. However the examiner has ignored the fact that Tomita has bulking agents that provided a sucrose equivalency that raises the "sugar" content of the Tomita product significantly higher than applicant's claimed invention. In examples 1-12 of Tomita, hydrolyzed starch powder is included in every formulation. As noted in ICE CREAM, by Marshall, Goff and Hartel, it is common to substitute sweeteners derived from starch for sucrose when making ice cream. See page 75 paragraph 1. The desired sweetness of ice cream, based on equivalency to sucrose ranges typically from 13 % - 16%. See page 73 paragraph 2. Starch is a high molecular weight polymer, but during the hydrolysis process its amylase and amylopectin are cleaved at the 1,4 glucosidic linkages reducing its molecular weight and producing a high dextrose equivalency. See page 75 paragraph 2. A pre-mix containing a starch with a high dextrose equivalency will result in an increased sucrose equivalency. See page 140 paragraph 3.

In Example 1 of Tomita, the sucrose content is 13%, but when hydrolyzed starch is added the sucrose equivalency is raised to 18%. In Example 2 of Tomita, the sucrose content is 15%, but when hydrolyzed starch is added the total sucrose equivalency is raised to 21.91%. In Example 12 of Tomita, the purified sugar content of the pre-mix is 9%, however once a hydrolyzed starch powder is added, the total sucrose equivalent content rises to 14%. All of these sucrose equivalencies are much closer to a typical bulk ice cream's sucrose equivalency of 20.45%, than the sucrose equivalency claimed in the present application.

Nowhere does Tomita teach, suggest or disclose a frozen dessert product comprising a single phase pellet premix which contains a sugar content of less than 8% and an artificial sweetener content which would allow a frozen dessert to maintain a single phase without fusing at temperatures of about -5°C to -10°C, or -18°C to -20°C, or -15°C to -18°C, or -25°C to -5°C as set forth in applicant's dependent claims.

Applicant respectfully submits that the present application is patentable over Cole in light of Jones, and Tomita. Cole's disclosure is directed towards a frozen dessert product which emulates the textural characteristics of soft serve ice cream. <u>See col. 1 lines 5-7</u>. Marshall explains in ICE CREAM that generally the sugar content of soft serve ice creams range from 13-15%. <u>See page 253 paragraph 3</u>. It is necessary to balance the sweetener content with the amount of lactose to provide the correct consistency. <u>Id. at 254 paragraph 1</u>. Thus, a disclosure directed towards soft serve ice cream could not be combined with the method disclosed by Jones because the level of sweetness is specifically tailored to provide a soft ice cream consistency, as opposed to the solid pellet disclosed by Jones.

Furthermore, although Cole discloses the use of a sweetener besides sucrose, nowhere does Cole teach suggest or disclose the combination of artificial sweeteners and sugars as set forth in applicant's dependent claims or for the same purpose. Cole discloses the use of carbohydrates which includes a combination of saccharides to depress the freezing point of the ice cream. See col. 6 lines 1 - 16. Cole only discloses that the level of carbohydrates from all sources to be between 24 % - 34 %. See col. 6 lines 14-15. Cole broadly defines a carbohydrate to include soluble compounds composed of carbon, hydrogen, and oxygen in which the latter two elements are in the same proportion as in water. See col. 2 lines 24-32. In Tables 1-6, Cole discloses a wide range of possible total saccharide contents which range from 22.1-28.5 %.

The main object of the present invention is to elevate the melting temperature of a frozen pellet dessert. See paragraph 0124. This is achieved through a single phased product that does not have added air in the premix as well as specific combination of natural sugars and artificial sweeteners. See paragraph 0124. One of the main distinguishing features of the present invention is the achievement of a warmer melting temperature without the addition of a bulking agent. See paragraph 0114. Intensive sweeteners such as sucralose and aspartame are included applicant's disclosure. See paragraph 0133.

The examiner also relies on Cole, U.S. Patent No. 4,374,154 which is directed to a soft serve ice cream that is dispensed from a package having an extrusion orifice. The product has a total saccharine or carbohydrate level of from about 24% to 34%. See col. 6 lines 14-15. The term carbohydrate used in Cole includes starch. See col. 2 lines 26-30. The product is intended to be served as a continuous ribbon via manual pressure

immediately upon removal from a freezer. The individual package which are intended to dispense the product are toothpaste type tubes, which when rolled up forces product through an extrusion orifice. In making the product the mix is passed through an ice cream freezer when "air or inert" gas "is incorporated into the product" because the overrun will usually "be within the range of 100-200%" See col. 4 lines 45-50.

In tables 1-6, Cole discloses the use of fructose or dextrose. As noted in ICE CREAM, by Marshall, Goff and Hartel, it is common to substitute sweeteners derived from starch for sucrose when making ice cream as Cole does. See page 75 paragraph 1. Starch is high molecular weight polymer, but during the hydrolysis process its amylase and amylopectin are cleaved at the 1,4 glucosidic linkages reducing its molecular weight and producing a high dextrose equivalency. See page 75 paragraph 2. A pre-mix containing a starch with a high dextrose equivalency will result in an increased sucrose equivalency. See page 140 paragraph 3. Fructose and Dextrose are usually characterized by high dextrose equivalency, and thus would generate a high sucrose equivalency in Cole's premix. See page 76 paragraphs 2-3.

Fructose or dextrose which is also a well known in the art as a bulking agent. See tables 1-6. The present application defines a bulking agent as necessary to maintain the processing and post processing characteristics that are essential to a bulk ice cream product. See paragraph 0113. Table 2.5 on page 33 of ICE CREAM lists additives which are well known in the art as bulking agents. ICE CREAM includes dextrose, fructose, sucrose, lactose, maltose, honey, and corn syrup as bulking agents. See page 33 table 2.5. One of the advantages of the present invention is that it does not require the use of a bulking agent to increase the melting point of the ice cream because the sugar content is

reduced. See paragraph 0114. In all of Cole's trials either fructose or dextrose was used, which ICE CREAM identifies as bulking agents which are well known in the art. See tables 1-6.

Cole also requires the presence of an additive containing protein. A formulation with insufficient protein does not whip well and is considered deficient in holding the desired overrun. See col. 5 lines 26-29. Cole's disclosure suggests that milk solids not as fat (hereinafter referred to as MSNF) as the preferred source of protein. See col. 5 lines 32-35. Used in the preferred composition, MSNF also provide the desirable property of lowering the freezing point and adding some sweetness. See col. 5 lines 36-37. In Cole the purpose of adding protection to the mix is to lower the freezing point, whereas applicant's composition raises the freezing point of the product. Thus Cole is structurally distinct from the present invention, and unable to combine with Jones because Cole requires MSNF to achieve a desired level of sweetness, freezing point, and soft consistency.

Thus, nowhere does Cole teach, suggest or disclose a premix which would allow a frozen dessert to maintain a single phase without fusing at temperatures of about -5°C to -10°C, or -18°C to -20°C, or -15°C to -18°C, or -25°C to -5°C as set forth in applicant's dependent claims.

Applicant respectfully submits that the use of high-potency sweeteners in the disclosed amounts in combination with the overall formulation should not be considered obvious in light of the prior art. As noted in ICE CREAM, by Marshall, Goff and Hartel, the use of high-potency artificial sweeteners are common in products where freezing point depression is not an important factor, but ice cream is a product in which freezing

point depression is very important. See page 78 paragraph 6. ICE CREAM, also explains that the use of a high-potency artificial sweetener in ice cream generally requires the presence of an additive which will depress the freezing point. Id. ICE CREAM, suggests Polydextrose as a potential candidate which can function as a bulking agent if a high-potency artificial sweetener is used. Id.

The initial freezing point of ice cream is highly dependent on the sweetener content of the mix used to make the ice cream. Id. at 49 paragraph 3. When conventional three phase ice cream is made, latent heat is removed from water causing ice crystals to form, and a new freezing point is established for the remaining solution since it has become more concentrated. Id. Figure 2.5 on page 50 in ICE CREAM demonstrates freezing point curves for different ice cream mixtures with different concentrations of sugars. Compositions with a low concentration of sugars have a higher percentage of their water frozen at retail cabinet temperatures and are thus not as soft as compositions with high concentrations of sugar at the same temperature. Thus, the single phase product of the present invention would have a lower sugar composition and a high percentage of its water frozen at conventional retail cabinet temperatures, which would make it impossible to serve it in the same method conventional three phase ice cream is served.

In both Tomita and Cole the presence of softness in their ice cream is critical. Air added to the premix provides the softness called for by these patents. Both Cole and Tomita claim a product that has air added. Tomita in fact specifically stresses the size of the air cells. See col. 6 lines 25-34. Tomita's disclosure is directed to an ice cream which has excellent softness and "is capable of being spooned up easily". See col. 1 lines 14-17. Applicant respectfully submits that Tomita teaches away from an ice cream composition

with a sugar content of less than 8% at the temperatures claimed by the present invention because the prior art indicates that this would reduce the softness of the ice cream, and his invention is directed to an ice cream which is "capable of being spooned up easily".

Cole's disclosure is directed towards a frozen dessert product which emulates the textural characteristics of soft serve ice cream. See col. 1 lines 5-7. Cole further discloses that softness is affected by the saccharide content such that more saccharide makes the ice cream softer. See col. 6 lines 5-11. Thus Cole teaches away from ice cream composition with a sugar content of less than 8% at the disclosed temperatures as set forth in applicant's dependent claims because the ice cream produced would be too hard for Cole's soft serve ice cream as the desired softness of soft serve ice cream would be non-existent.

Jones teaches a method for forming a pelletized dessert product comprising introducing a premix into a body of liquid cryogen. See col. 2 lines 16-29. But Jones does not teach or suggest the level of sugar remaining composition which allows the pellets to remain in a solid phase from -25°C to about -5°C as set forth in applicant's dependent claims. Thus the use of high-potency sweeteners in the disclosed amounts in combination with the overall formulation is not obvious in light of the prior art.

Claims 35-37, 39, 41, and 43-45 depend either directly or indirectly on independent claim 34. For the reasons that independent claim 34 is patentable, applicant respectfully suggests claims 35-37, 39, 41, 43-45 are also patentable.

Applicant has also amended independent claim 46 to better point out the distinctions between the claimed invention and the prior art. For example, claim 46 now covers a method of forming a frozen dessert product comprising introducing small

individual volumes of liquid of a premix into a cryogen causing the small individual volumes of liquid to completely freeze in a generally spherical shape, the pellets consisting essentially of pre-mix, and remaining exclusively in a solid phase at a temperatures from about -25°C to about -5°C . Jones, Tomita, and Cole were discussed above in reference to independent claim 34. Applicant hereby incorporates by reference the arguments made regarding the differences between the prior art and independent claim 34 previously herein. For the same reasons independent claim 34 is patentable, applicant respectfully submits that claim independent claim 46 is patentable.

Claims 47-51, 53, and 55-57 depend either directly or indirectly on independent claim 46. For the same reasons that independent claim 46 is patentable, applicant respectfully submits that claims 47-51, 53, and 55-57 are also patentable.

Applicant has also amended independent claim 58 to better point out the distinctions between the claimed invention and the prior art. For example, claim 58 now covers a method of forming a frozen dessert product consisting essentially of premix, comprising introducing small individual volumes of liquid of a premix into a body of liquid cryogen, the small individual volumes of liquid completely freezing, and remaining in a solid phase from about -35°C to about -5°C. Jones, Tomita, and Cole were discussed above in reference to independent claim 34. Applicant hereby incorporates by reference the arguments made regarding the differences between the prior art and independent claim 34 previously herein. For the same reasons independent claim 34 is patentable, applicant respectfully submits that claim independent claim 58 is patentable.

Claims 59-66, and 69-79 depend either directly or indirectly on independent claim 58. For the same reasons that independent claim 58 is patentable, applicant respectfully submits that claims 59-66, and 69-79 are also patentable.

CONCLUSION

For the foregoing reasons, Applicant requests reconsideration of the rejection.

Respectfully submitted,

Thomas A. O'Rourke
Reg. No.: 27,665
Bodner & O'Rourke, LLP
425 Broadhollow Road
Melville, NY 11747

Application No. 10/787,253

CERTIFICATE OF MAILING

I hereby certify that the foregoing Response was mailed by first class mail, postage prepaid, in an envelope addressed to the Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450 on this 10th day of July, 2009.

Thomas A. O'Rourke

ə allowed to grow sufficiently large
mix is about 6% if no whey pow-
əls of lactose in ice cream mix in
nt (causing a soft ice cream and
ciness) and a greater potential for
ctose solubility in water at room
this concentration is exceeded as
val in the form of ice). When 75%
ginally of 11% NMS (6% lactose),
responds to ~40%. Probably much
saturated, amorphous (non-crys-
sity. Stabilizers help to hold lac-
ement of viscosity.

ase the acceptance of the product
asing creamy flavor and the del-
es a flat taste; too much tends to
ount of sweetness expressed as
–16% is usually most desirable.
tal solids (TS) of the mix. This
m, provided the TS content does
es not exceed about 16%. Above
oo soft or too dense and chewy,
. Sweeteners, being in solution,
results in the desirable soft,
frozen product. It also results in
ning. In addition to their effect
except the non-nutritive or low
e of TS in the mix. Sucrose, like
in the supersaturated or glassy

ening agent added to ice cream;
l in comparing the sweetening
test of sweetness, and not all
rious sweeteners. The common
igars to sucrose, which is given
s of commonly used sweeteners
easing tendency to obtain the
er sweeteners. This blending is
ther more economically priced
total solids of some ice creams
etness. The percentage of the
er sources is influenced mainly
in the mix, (2) the total solids
ies of the mix, such as freezing
ncentration in the sweetener of

Table 2.5. Sweeteners and Bulking Agents for Frozen Desserts

Ingredient	Average molecular weight[a]	Relative sweetness[b]	Total solids (%)	Relative F.P. depression[c]	Maximum total sugar supplied[d] (%)
Dextrose	180	74	92	1.90	40
Fructose	180	173	100	1.90	40
Sucrose	342	100	100	1.00	100
Lactose	342	16	100	1.00	g
Maltose	342	32	100	1.00	—
Honey	—	75	74	1.46	45
Invert sugar	261	95	77	1.12	30
HFCS[e]					
90%	180	125	77	1.88	50
55%	185	98	77	1.85	50
42%	190	86	71	1.80	50
HMCS[f]					
55 DE	411	55	81	0.83	40
Corn syrups					
68 DE	265	72	81	1.28	25–50
62 DE	298	68	82	1.15	25–50
52 DE	345	58	81	0.99	25–50
42 DE	428	48	80–81	0.80	25–50
36 DE	472	42	80	0.72	25–50
32 DE	565	40	80	0.61	25–50
25 DE	720	28	80	0.48	h
20 DE	900	23	80	0.38	h
Maltodextrins					
18 DE	1000	21	95	0.34	h
15 DE	1200	17	95	0.29	h
10 DE	1800	11	95	0.19	h
5 DE	3600	6	95	0.10	h

[a]Average molecular weights of CSS and maltodextrins are estimated by dividing the average molecular weight of starch, 18,000, by the dextrose equivalent (DE) factor.
[b]Sweetness relative to sucrose (approximate) on an as is or product basis.
[c]Factor to estimate freezing point depression relative to solids equal in weight to sucrose.
[d]Percent of sugar on a sweetness basis generally acceptable from a quality viewpoint.
[e]HFCS—High-fructose corn syrup.
[f]HMCS—High-maltose corn syrup. 65% maltose.
[g]Lactose provides low sweetness but amount is limited by tendency to crystallize.
[h]Lower DE cornstarch products build body and provide bulk rather than sweetness.

substances other than sugar (e.g., the undesired flavor of honey or the undesired color of molasses), and (5) the relative sweetness of the added sweetener. For most ice cream formulations the sweeteners can be either sucrose (cane or beet sugar) alone or sucrose in combination with some product of hydrolyzed corn starch.

Because sugars do not dissociate in solution, the freezing point of solutions of them can be computed from the concentration and molecular weight (see Chapter 5, Mix Calculations). With given weights and volumes of solvent, the effect on freezing point will be inversely proportional to the molecular weight. For example, monosaccharides (e.g., dextrose) have 6 carbons, whereas disaccharides (e.g., sucrose, containing glucose and fructose) have 12 carbons. Thus, a single molecule of sucrose weighs nearly twice as much as dextrose (glucose)

:hapter 3. High heat treatment
ıs increasing mix viscosity and

x manufacture for many years.
zers in proprietary blends but
m those of stabilizers. They are

ɜducing aging time;
ↄ their function at the air interface,
geneous distribution of air in the

ınce fat destabilization, facilitating
:acture;
.tdown, due to a combination of the

se/icy textures, due the effect of fat
thinner lamellae between adjacent
ıls;
ct, due to fat structuring and the
during consumption.

stable suspension of two liquids
er. In ice cream mixes, there is
ify the mix, so emulsifiers are
ic sense. Their mechanism of
summarized as follows: they
mix, resulting in protein dis-
in turn, reduces the stability of
:ing the whipping and freezing
re of the fat in the frozen prod-
ıeltdown properties (Goff and
ıent from the membrane, and
:tion of the emulsifier concen-
.ers in structure formation will
itled "Fat Destabilization and

increasing the nutritive value
ɜxture of the ice cream. This is
to added carbohydrates, sweet
ɜ, like sweet cream buttermilk
ı the freezing time. Increasing
ɔf frozen water and frequently
he minimum of 1.6 lb of food
ıoggy product may result when

the TS content is too high, i.e., above 40–42%. Furthermore, displacement of water with TS results in a warmer product.

Water and Air

Water and air are important constituents of ice cream, but their effects are easily disregarded. Water is the solvent for the continuous phase. In frozen ice cream, it is present both as a liquid and a solid, as it will not completely freeze due to the effect of the added solutes on freezing point depression. The solid : liquid ratio, as dictated by solute concentration and temperature, greatly affects the firmness of the ice cream. Water in the ice cream mix comes from fluid dairy products and syrups or from added water.

The air is dispersed through the fat-in-serum emulsion. The interface between the water and air is stabilized by a thin film of unfrozen material, comprised of protein and emulsifier, and by partially churned fat globules (see further details in section "Fat Destabilization and Foam Formation"). In the manufacture of ice cream, overrun, the increase in volume of ice cream over the volume of mix used, is produced by incorporation of air. The amount of air in ice cream influences both quality and profits and is involved in meeting legal standards. Therefore, maintaining the targeted uniform amount of incorporated air is essential. Air filters are used on continuous freezers to remove particulates from air entering the freezer.

Studies have been conducted on gases other than air in ice cream. Liquid nitrogen (N_2) can be injected into the mix during the freezing process to rapidly cool and replace air. Im and Marshall (1998) found no decrease in the rate of oxidation when nitrogen was substituted for air in light ice cream made with 4.5% milkfat and 0.5% fish oil (a source of omega-3 fatty acids). However, a similar experiment showed a significant reduction in both oxidized flavor and amount of hexanal produced when gaseous nitrogen was used to replace air during freezing of a mix in which canola oil and soybean oil were used to replace 60% of the milkfat in a mix containing 12% total fat. Others who added finely shredded solid carbon dioxide (CO_2) to ice cream during the manufacturing process to replace the air claimed an improved product.

IMPORTANCE OF FLAVOR

Flavor is generally considered the most important characteristic of ice cream. It is easily confused with taste, which includes the "feel sensation" of body and texture as well as the true flavor. The flavor of ice cream is the result of blending the flavors of all the ingredients, some of which may not be sufficiently pronounced to be recognizable, although each contributes to the final effect. This makes it difficult to predict the effect of a certain ingredient upon the flavor of the ice cream. Furthermore, the desirability of a particular flavor, or more properly "blend of flavors," depends upon the individual doing the tasting.

Flavor has two important characteristics: type and intensity. Flavors that are delicate and mild are easily blended and tend not to become tiresome even when very intense, while harsh flavors soon become tiresome even in low concentrations. As a general rule, therefore, delicate flavors are preferable to harsh ones; but in any case the flavor should be delicately pleasing to the taste

and ice crystals do not mechanically interrupt and weaken the lamellae of the air cells. Therefore, as freezing starts, it is required that fat globules be small and well dispersed. However, to prevent collapse of the foam, especially during storage, and to produce dryness and stiffness, it is vital that fat globules be partially destabilized.

The size, number and physical condition of fat globules in an ice cream mix determine the rate of whipping and the stability of the whipped product. Small fat globules and limited clumping enhance whipping. Nonfat mixes whip more rapidly than those containing fat, but when frozen, they possess a foam structure that is susceptible to shrinkage. Partial coalescence of the fat of ice cream during freezing produces a bridging structure that provides resistance to shrinkage. Protein from NMS is important for whipping. Factors that lead to loss of protein functionality, such as excessive heat and denaturation or poor solvent quality from ethanol addition, for example, may adversely affect the whipping properties of the protein. Added sodium caseinate improves whipping properties and affects air cell and ice crystal distribution to an extent hardly expected of any other commonly used ice cream constituent. However, high levels of caseinate may lead to insufficient fat destabilization, due to its excessive adsorption at the fat interface. Egg yolk solids and buttermilk solids from sweet cream improve whipping ability, presumably due to lecithin existing as a lecithin-protein complex. Emulsifiers also improve whipping ability. Finally, the design and operation of the freezer determine whether the maximum whipping ability of a given mix is obtained.

Freezing Point

The freezing point of ice cream is dependent on the concentration of the soluble constituents and varies with the composition. The freezing temperature can be calculated with considerable accuracy (see Chapter 5, Mix Calculations) and can be determined in the laboratory with a cryoscope or a vapor pressure osmometer.

An average mix containing 12% fat, 11% NMS, 15% sugar, 0.3% stabilizer, and 61.7% water has a freezing point of approximately −2.5°C (27.5°F). The freezing point of mixes with high sugar and NMS content may range downward to −3°C (26.5°F) while for mixes with high fat, low NMS, or low sugar content it may range upward to −1.4°C (29.5°F). Based on mix compositions typical at the times, Tharp (1982) calculated freezing points of mixes for the years 1950, 1960, 1972, 1975, 1980 and 1981. They were 27.70, 27.00, 27.17, 27.07, 26.47 and 25.77°F, respectively. Differences in amounts of sweetener solids and lactose concentration used in the mixes were suggested as primarily responsible for the differences in freezing points.

The initial freezing point of the ice cream mix is highly dependent on the sweetener content of the mix. When latent heat is removed from water and ice crystals are formed, a new freezing point is established for the remaining solution since it has become more concentrated in respect to the soluble constituents. A typical freezing curve for ice cream shows the percentage of water frozen at various temperatures (Figure 2.5). Calculations for generating such a curve are demonstrated in Chapter 5.

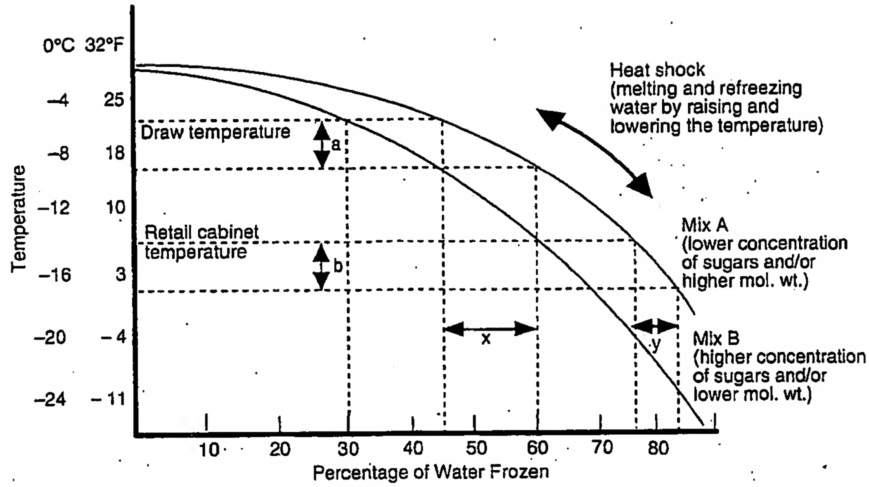


Figure 2.5. Typical freezing curve for ice cream mixes of varying composition showing the percentage of water frozen at various temperatures.

REFERENCES

Barfod, N. M., N. Krog, G. Larsen, and W. Buchheim. 1991. Effects of emulsifiers on protein-fat interaction in ice cream mix during ageing. I: Quantitative analyses. *Fett-Wissenschaft-Technologie*. 93:24–35.

Bitman, J., and D. L. Wood. 1990. Changes in the milk fat phospholipids during lactation. *J. Dairy Sci.* 73:1208.

Bolliger, S., H. D. Goff, and B. W. Tharp. 2000. Correlation between colloidal properties of ice cream mix and ice cream. *Internat. Dairy J.* 10:303–309.

Boode, K., and P. Walstra. 1993. Partial coalescence in oil-in-water emulsions. 1. Nature of the aggregation. *Colloids Surfaces A.*, 81:121–137.

Boode, K., P. Walstra, and A. E. A. deGroot-Mostert. 1993. Partial coalescence in oil-in-water emulsions. 2. Influence of the properties of the fat. *Colloids Surfaces A.*, 81:139–151.

Budiaman, E. R., and O. R. Fennema. 1987a. Linear Rate of water crystallization as influenced by temperature of hydrocolloid suspensions. *J. Dairy Sci.* 70:534–546.

Budiaman, E. R., and O. R. Fennema. 1987b. Linear Rate of water crystallization as influenced by viscosity of hydrocolloid suspensions. *J. Dairy Sci.* 70:547–554.

Buyong, N., and O. R. Fennema. 1988. Amount and size of ice crystals in frozen samples as influenced by hydrocolloids. *J. Dairy Sci.* 71:2630–2639.

Caldwell, K. B., H. D. Goff, and I
electron microscopy study of ice
Food Struc. 11:1–9.

Caldwell, K. B., H. D. Goff, and I
electron microscopy study of ice
processes. *Food Struc.* 11:11–23.

Chen, J., and E. Dickinson. 1993
proteins and surfactants in oil in

Conforti, F. D. 1994. Effect of fat
attributes and shelf stability of v

Courthaudon, J.-L., E. Dickinson, a
β-casein and nonionic surfactant
145:390–395.

Dalgleish, D. G., M. Srinivasan, an
emulsion droplets containing
43:2351–2355.

Donhowe, D. P., and R. W. Hartel.
controlled accelerated storage. *In*

Donhowe, D. P., and R. W. Hartel. 1
ice cream. *Internat. Dairy J.* 6:12

Dubey, U. K., and C. H. White. 1997

El-Rahmán, Abd A. M., S. A. Mad
characteristics of frozen desserts
fractions. *J. Dairy Sci.* 80:1926–1

Euston, S. E., H. Singh, P. A. Munro
between sodium caseinate and
water emulsions. *J. Food Sci.* 60:

Euston, S. E., H. Singh, P. A. Munro
stabilized by sodium caseinate or
stearate. *J. Food Sci.* 61:916–920.

Flores, A. A., and H. D. Goff. 1999a.
model solutions and ice cream as

Flores, A. A., and H. D. Goff. 199
and cycling temperature storage
82:1408–1415.

Frandsen, J. H., and E. A. Markha
Orange Judd Publ. Co., New York

Gelin, J.-L., L. Poyen, J.-L. Courtha
changes in oil-in-water emulsio
Hydrocoll. 8:299–308.

Gelin, J.-L., L. Poyen, R. Rizzotti, C
Interactions between food compo
tionships. *J. Texture Studies*. 27:1

Gelin, J.-L., L. Poyen, R. Rizzotti, M.
Interactions between food compon
Hydrocoll. 10:385–393.

Goff, H. D. 1997. Colloidal aspects o

Goff, H. D. 2002. Ice cream. In P. F.
Chemistry—1. Proteins, 3rd ed. N

Goff, H. D., and W. K. Jordan. 1989.
during the manufacture of ice cre

Goff, H. D., M. Liboff, W. K. Jordan,
80 on the fat emulsion in ice
microscopy studies. *Food MicroStr*

Goff, H. D., J. E. Kinsella, and W.
isolates on ice cream emulsion sta

Goff, H. D., R. D. McCurdy, and G. N
cream. *Modern Dairy*, 69(3):17–18

deficiencies are lack of creaminess, milkfat flavor and ability to carry fat-soluble flavors.

SWEETENERS

Many kinds of nutritive sweeteners are used in ice cream (Table 2.5). They include cane and beet sugars, many types of corn sweeteners, maple sugar, honey, invert sugar, fructose, molasses, malt syrup, brown sugar, and lactose. The most common choice of sweetener system in mixes is a combination of sucrose (10–12%) and corn sweeteners derived from hydrolysis of corn starch (corn syrup solids, CSS, usually 3–5%). The major considerations in blending sweeteners are relative sweetness, contribution to total solids and freezing point depression of the mix. The desired sweetness of ice cream, based on equivalency to sucrose, ranges from 13 to 16%. Sweetness depends on the concentration of sweetener in the water of the mix; thus, decreasing the water of the mix is equivalent to increasing the sweetness. Sweeteners, being dissolved, lower the freezing point of the mix and this leads to an increased rate of melting. High levels can also reduce whippability, especially important for batch freezer operation.

Sucrose, Crystalline and Liquid

Sucrose, commonly known as granulated sugar, is made from sugar cane or sugar beets. Being crystalline, it is approximately 99.9% solids. It is highly soluble and has a density of 1.595 g/mL. Sucrose is available also as a syrup containing approximately 67% solids. Sucrose concentrations in mix formulations are limited by high levels of contributed sweetness. Sucrose depresses the freezing point; each 1% increase in sucrose in an ice cream mix lowers the freezing point about 0.1°C (0.2°F). Sucrose may be used as the sole sweetener in ice cream with excellent results, especially in high solids (e.g. premium or superpremium) formulations where the additional body from corn syrup solids is not wanted. However, use of sucrose as the sole sweetener in ices or sherbets may result in formation of crystals on the surfaces. This defect in ices and sherbets can be avoided by using one part of dextrose to 3.5 parts of sucrose.

Syrups or liquid sweeteners provide the convenience of handling in large systems, since the metering of them can be controlled with computers and in-line metering devices. The total solids content of sucrose syrups is usually measured by °Brix, which assumes all the solids to be sucrose. This is a safe assumption for practical purposes. Most other syrups are measured by °Baumé. This number is based on the specific gravity of the syrup and, therefore, is also a measure of the TS concentration. However, °Baumé does not reflect the kind or amounts of the sugars and dextrins present. Baumé and Brix are related for sucrose syrups as shown in Table 3.6. Baumé reading must be converted to specific gravity before TS can be calculated (Table 3.7). Specific gravity is the ratio of the density of a liquid to the density of water at a given temperature, which for syrups is 39°C. It is given by $145/(145 - d)$ where d is the °Baumé reading at 68°F.

to Brix (Sucrose Syrups)

Sugar (lb/gal)	Water[b] (lb/gal)
6.58	4.20
6.71	4.12
6.85	4.03
6.98	3.94
7.12	3.85
7.26	3.76
7.41	3.66
7.56	3.57
7.70	3.48
7.85	3.38
8.00	3.28
8.15	3.18
8.30	3.09
8.45	2.99
8.61	2.88

the column by 0.12.
0°C) weighs 8.322 lb.

stants of Corn Syrups

Weight (lb/gal)	Solids (lb/gal)
11.700	9.084
11.813	9.402
11.928	9.725
12.045	10.059
12.163	10.389
11.700	9.161
11.813	9.482
11.928	9.811
12.045	10.148
12.163	10.492
11.700	9.236
11.813	9.561
11.928	9.895
12.045	10.236
12.163	10.586
11.700	9.312
11.813	9.642
11.928	9.980
12.045	10.325
12.163	10.679

Corn Sweeteners

It has become common practice in the industry to substitute sweeteners derived from corn starch or other starch sources such as potato, tapioca, rice, oat or wheat for a portion or all of the sucrose. A typical sweetener blend for an ice cream mix usually includes 10–12% sucrose and 3–5% corn syrup solids (corn starch hydrolysate syrup, commonly referred to as "glucose solids", but not to be confused with glucose, the monosaccharide). The use of corn syrup solids in ice cream is generally perceived to provide enhanced smoothness by contributing to a firmer and more chewy texture, to provide better meltdown characteristics, to bring out and accentuate fruit flavors, to reduce heat shock potential which improves the shelf life of the finished product, and to provide an economical source of solids (Goff et al., 1990a,b).

Starch is a high molecular weight polymer of the monosaccharide glucose (also known commonly as dextrose), and is comprised of two fractions, amylose, a linear fraction, and amylopectin, a branched fraction. During the hydrolysis process, amylose and amylopectin are continually and systematically cleaved at the 1,4 glucosidic linkages by enzymes (randomly by alpha amylase to reduce total molecular weight, and sequentially by either glucoamylase to produce dextrose or beta amylase to produce maltose) resulting in controllable mixtures of medium (oligosaccharides) and low (dextrose, maltose, maltotriose, etc.) molecular weight units (Figure 3.3). Each bond hydrolyzed produces a free aldehyde group that has the same reducing ability as does dextrose. This makes it possible to monitor the process of hydrolysis, the extent of which is termed the dextrose equivalent or DE.

Maltodextrins are only slightly hydrolyzed; consequently they range in DE from 4 to 20 and are only slightly sweet. Maltodextrin can be used in the production of lowfat frozen desserts where it is desirable to find ingredients that contribute greatly to body in low solids formulations. There are several maltodextrin ingredients available that are specifically designed for lowfat systems. The medium molecular weight saccharides (dextrins) are effective stabilizers and slow the formation of large ice crystals, thus improving heat

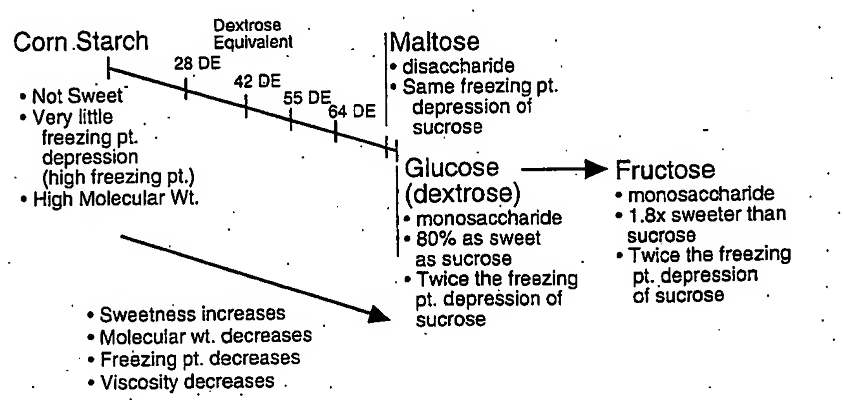


Figure 3.3. An illustration of the products that result from the hydrolysis of corn starch and their properties relevant to ice cream manufacture.

shock resistance. They also improve cohesive and adhesive textural properties, resulting in positive contributions to the body and meltdown of ice cream. The smaller molecular weight sugars provide smoothness, sweetness, and flavor enhancement. Dextrose, being a monosaccharide, causes greater freezing point depression than sucrose, maltose or lactose. With the appropriate use of enzyme technology, corn syrup manufacturers have the ability to control the ratios of high to low molecular weight components, and the ratios of maltose, the disaccharide, to dextrose, the monosaccharide. High maltose syrups reduce the effect of dextrose on freezing point.

Starch hydrolysate products having 20 to about 70% of the glucosidic linkages broken are known as corn syrups. They are classified based on degree of conversion as low conversion, 28–38 DE; regular conversion, 39–48 DE; intermediate conversion, 49–58 DE; and high conversion, 59–68 DE. The ratio of higher to lower molecular weight fractions can be estimated from the dextrose equivalent (DE) of the syrup. Figure 3.3 shows that as the DE increases, the sweetness increases but the freezing point decreases, and the contribution to viscosity and chewiness in the mouth decreases. Thus, optimization of DE and concentration of corn sweeteners are required for the most beneficial effects. These sweeteners are available in liquid (~80% solids) or dried form. Dry products are also available that have been agglomerated to produce powders with high wettability and little dust. Ice cream manufacturers usually use liquid or dry corn syrup products with a 28–42 DE.

With further enzyme processing (using glucose isomerase), dextrose can be converted to fructose (Figure 3.3), as in the production of high fructose corn sweeteners (HFCS). The resultant syrups are much sweeter than sucrose, although they have more monosaccharides and thus contribute more to freezing point depression than does sucrose. The most commonly used type is HFCS 42. It contains 42% fructose, 52% dextrose and 6% higher saccharides. HFCS 90 is a super sweet mixture of 90% fructose, 7% dextrose and 3% higher saccharides. Compared with sucrose, high fructose corn syrups (42, 55 and 90%) are from 1.8 to 1.9 times as sweet and lower the freezing point nearly twice as much (Table 2.5). Satisfactory use of HFCS requires optimization of the concentrations of all sweeteners. It has been shown that blends of high fructose syrup, high maltose syrup and low DE syrup can be utilized to provide appropriate sweetness, freezing point depression and total solids, in the absence of sucrose.

Pure crystalline glucose (dextrose) and fructose are also available from the corn sweetener industry. These are both monosaccharides and thus should not be used alone. They can be used in combination with other sweeteners to achieve the desired freezing point depression and ice cream firmness. Dextrose is a white granular material that contains approximately 99.8% sugar solids. Because it is only about 80% as sweet as sucrose, 1.25 parts of dextrose are required to replace 1 part of sucrose. Dextrose lowers the freezing point nearly twice as much as does sucrose on a weight for weight basis, because it has about one-half the molecular weight of sucrose.

Maple and Brown Sugars

Maple and brown sugars contain characteristic flavoring components that limit their use in ice cream. For example, only 6% of maple sugar in the mix

will produce a distinct maple f
their comparative high cost.
Both maple and brown sugar
about 86% sucrose, 10% moist
contains about 52% sucrose, 45

Honey is comprised of about 7
2% dextrin and 4% miscellaneo
provide honey flavor. Usually b
be provided by 9 kg honey a
flavor may blend poorly with c
to honey-flavored ice cream is s

S

The group of mono- and di-s
sorbitol, mannitol, xylitol, ery
related hydrogenated starch hy
Dalzell (1996) and Nabors (2001
low sugar or sugar free formulat
glycemic index than convention
diets of insulin-dependent diab
agents, sweeteners, and crysta
their relative sweetness, freezin
(cooling effect), stability, laxatio
polyols are considered fully
Community recognizes a caloric
all polyols for labeling purposes.
caloric content is permitted, an
FDA are 2.6 kcal/g for sorbitol,
2.1 kcal/g for maltitol, 2 kcal/g f
Sorbitol and mannitol are mo
juices of apples, pears, cherries
of manna, an exudate of the as
marine algae. Sorbitol and man
glucose and fructose, respectivel
sweet while mannitol is 0.5× as
mannitol is not. They both prov
negative heat of solution. As m
point depression effect as sucro
recognized as safe (GRAS) in th
Canada, the European Union an
olds, in g/day, are considered to
During digestion, small am
absorbed through the wall of the
However, most of the utilization
verted to volatile fatty acids by b

pathways without dependence on insulin, polyols do not cause appreciable increases in blood glucose levels when eaten.

Maltitol differs from sorbitol and mannitol in its physical properties because it is hydrogenated maltose, a disaccharide. It provides similar freezing point depression and sweetness as sucrose and does not provide the cooling effect of sorbitol and mannitol. Its laxation threshold is set at 100 g/day before a warning label must be used. It is widely approved for food use in many countries.

Xylitol is a five-carbon polyol with similar sweetness as sucrose. It is the sweetest of the polyols and has the most cooling effect. As a lower molecular weight sweetener than the monosaccharides, it could not be used in ice cream at a one-to-one replacement for sucrose due to its freezing point depression effect.

Lactitol is the product of hydrogenation of lactose, thus also a disaccharide polyol. Thus it has similar freezing point characteristics to sucrose, but it has only 0.3–0.4× the sweetness of sucrose. Its use is permitted in most countries.

Isomalt forms when sucrose is enzymatically rearranged to isomaltulose and the latter is hydrogenated. Sorbitol and mannitol are equimolar building blocks of isomalt. It is approximately one-half as sweet as sucrose and is non-cariogenic but tends to crystallize because of low solubility in water (25% at 20°C compared to 67% for sucrose).

Nonnutritive Sweeteners

Many high-potency sweeteners are either commercially available or are in various stages of testing and regulatory approval. They are used successfully in some products, soft drinks for example, where sweetness is desired but total solids and other physical characteristics of sucrose, e.g., freezing point depression, are not important. In ice cream and related products, however, total solids and freezing point depression are very important factors to consider when replacing sugar for caloric reduction. It is perhaps easy to find a high potency sweetener to replace the sweetness of sucrose and corn syrup solids, but what is then used to produce freezing point depression and to build total solids without contributing calories? Polydextrose is one such low-calorie bulking agent that can be used at a significant concentration without greatly affecting viscosity, but it contributes little to freezing point depression. Another factor to consider in looking at sugar replacement for caloric reduction is that the sugars contribute only a small fraction of the calories in frozen desserts compared to the contribution of fat. Therefore, fat replacement should be targeted first and sugar replacement only if further reductions are required. The more common high potency sweeteners are described below, but these limitations to their use should be recognized. They are extensively described in Dalzell (1996) and Nabors (2001). Some of them are in fact digested and thus caloric, but they are often considered non-nutritive due to the very low concentrations required in foods to provide adequate sweetness.

Saccharin, discovered in 1879 at Johns Hopkins University, is an organic compound approximately 300 times as sweet as sucrose. It can withstand long periods of storage as well as heat and is the least expensive of the nonnutritive sweeteners. It has been thoroughly studied throughout its history and

has been declared safe by num
more than 100 countries inclu

Aspartame was discovered
develop an anti-ulcer medici
L-aspartic acid (aspartate) and
in foods. Furthermore, it is dig
However, it contributes few c
low concentration of it needed
as sweet as sucrose). Asparta
It shows sweetness synergy wi
acesulfame K, and enhances
ronments, aspartame underg
is not an issue in the normal
100 scientific studies were c
made to the U.S. Food and D
thoroughly studied food additi
disease phenylketouria (PKU)
all sources, including asparta
nosed at birth by a blood test
use in foods may introduce a n
containing this sweetener m
Aspartame has been declared
FAO/WHO Expert Committee
the regulatory agencies of mo
ing the United States and the

Acesulfame potassium (aces
and nitrogen. It is 150–200 ti
the human digestive system
noncaloric. It is now widely ap
stable and soluble, does not de
ening effect with aspartame,
Since both acesulfame K and a
a salt, it is possible to produce
erties. Chemically-combined m
shown to provide a sweetness

Sucralose is the generic nam
derived from sucrose through c
on the average, 600 times sw
beverages including frozen de
decreases with increased swee
temperature. It remains stabl
ranges common to frozen desser

Ordinary salt is sometimes u
except in certain flavors such

Jaskulka et al. (1995) developed a method for predicting freezing points for a wider variety of formulations using an empirical model, based on actual measurement with an osmometer of freezing point of 110 mixes with a wide variety of ingredients and composition. The quadratic model contained as many as 19 terms, based on composition. With some ingredients present in a mix, their model was claimed to be more accurate than the one presented here.

The method presented here can also be used to calculate the amount of water frozen into ice for a given ice cream at any temperature by varying the solute concentration since freeze concentration of the unfrozen phase occurs during freezing. For a typical ice cream, a relationship between temperature and the amount of water frozen into ice, the freezing curve, is obtained (see Chapter 7). Based on the freezing point curve and the assumption of an equilibrium ice content, the amount of water converted to ice at any temperature can be calculated by a mass balance (Bradley, 1984).

Freezing Point Depression of a Mix

To calculate the freezing point of a given mix, the first step is to determine the equivalent content of sucrose in the mix, based on all the mono- and disaccharides that are present. This is referred to as the sucrose equivalence (SE) in g/100 g of mix.

$$\begin{aligned} SE = {} & (NMS \times 0.545) + (WS \times 0.765) + S + (10\ DE\ CSS \times 0.2) \\ & + (36\ DE\ CSS \times 0.6) + (42\ DE\ CSS \times 0.8) \\ & + (62\ DE\ CSS \times 1.2) + (HFCS \times 1.8) + (F \times 1.9) \end{aligned}$$

where:

NMS = nonfat milk solids; 0.545 is the percentage of lactose typical of NMS;
WS = whey solids (from dry or condensed whey), 0.765 is the percentage of lactose typically found in whey solids;
S = sucrose or other disaccharides such as lactose or maltose added directly;
DE = dextrose equivalence of the CSS (corn syrup solids);
HFCS = high fructose corn syrup;
F = pure fructose or other pure monosaccharides such as dextrose;
all in g/100 g mix (or %).

If blended protein, lactose and mineral ingredients are used as a source of NMS, the lactose and salts in those ingredients should be included directly in the calculation rather than using the factors for NMS or WP. Simply ensure that all lactose and salts are accounted for and none are double-counted.

The equivalent concentration of sucrose in water (g/100 g water) is then determined by dividing the SE by the water content.

$$\text{g sucrose/100g water} = SE \times 100/W$$

where W is the water content (100 − total solids, %).

To obtain the freezing point depression associated with this concentration of SE in water, FPD_{SE}, Table 5.1 is used.

Table 5.1. Freezing Point Depr (g/100 g water). Data Were Extra Originally Deriv

g Sucrose/100 g water	FPD (°C)	g Sucro water
3	0.18	6
6	0.35	6
9	0.53	6
12	0.72	7
15	0.90	7
18	1.10	7
21	1.29	8
24	1.47	8
27	1.67	8
30	1.86	9
33	2.03	9
36	2.21	9
39	2.40	9
42	2.60	10
45	2.78	10
48	2.99	10
51	3.20	111
54	3.42	114
57	3.63	117
60	3.85	120

The contribution to freezing point found using the following equation:

$$FPD_{SA} = \frac{(N\ldots}{}$$

Here, FPD_{SA} is the freezing point de and WS, and the constant 2.37 is ba concentration of the salts present in 4.26 is used. To obtain the freezing FPD_T, the two contributions are sum

$$FPD_T = F\ldots$$

Example Problem 12. Calculate t mix containing 10% NMS, 2% whey 60% water (40% total solids).

First, calculate the sucrose equivalen

$$SE = (10 \times 0.545) + (2 \times 0.\ldots$$

The equivalent concentration of sucro

g sucrose/100 g water =

7
The Freezing Process

Freezing the mix is one of the most important operations in making ice cream, for upon it depend the quality, palatability, and yield of the finished product. Typically, freezing of ice cream is accomplished in two steps: (1) dynamic freezing, where the mix is frozen quickly while being agitated to incorporate air and to limit the size of ice crystals formed; and (2) static freezing, where the partially frozen product is hardened without agitation in a special low-temperature environment designed to remove heat rapidly. Although these steps primarily encompass freezing, or the formation of ice crystals, there are several other important processes that take place during this time that significantly impact the quality of ice cream. Both the dispersion of air bubbles and rearrangement of fat globules occur during the freezing steps.

The general procedure of the dynamic freezing process involves accurate measurement of the ingredients, movement of them into the freezer, operation of the freezer and removal of frozen product from it. Mastering the details of freezer operation, however, to produce a uniformly high-quality product requires considerable practice. Several variables must be controlled simultaneously, and even with highly sophisticated programmable control on the freezers, there are still slight variations in product characteristics from day to day.

PREFREEZING TESTS

Before mixes are frozen they should be tested to determine whether the composition meets the specifications of the formula. Recommended methods of testing are found in Standard Methods for the Examination of Dairy Products. They are the ether extraction method for fat (15.8E,F) and the vacuum or forced draft oven methods for total solids (15.10A,C; Bradley et al., 1993).

GENERAL FREEZING OPERATIONS

In the dynamic freezing step, cold, flavored ice cream mix enters the cylindrical freezer barrel and is chilled with a liquid refrigerant, as shown schematically in Figure 7.1. The mix is whipped with a dasher, a mixing device with

r dispersion (number, size and
ocess. One way to think about
ı versus growth of crystals. To
ng conditions must promote
rth (Hartel, 2001). Promoting
t the appropriate point in the
nia or freon) are used to pro-
apid nucleation in the freezer.
been developed to promote ice
based on liquid nitrogen are
onditions that minimize their
as possible. Our understand-
rrel of a freezer is still some-
ıes is mandatory to maintain
. (1999) clearly demonstrated
in the freezer and ice crystal
ssary to have the shortest res-
ıount of ripening that occurs
dence time in the freezer and
with high throughput rates
dasher type and of operating
r than size of ice crystals.
he ice cream mix affect the
nts can influence ice crystal
s: (1) effect on freezing point
llization mechanisms (nucle-
pter 2, freezing point depres-
lar weight components in the
d salts lead to lower freezing
erature. A mix with low freez-
w amount of ice crystals. The
impact the mechanisms of ice
ve been shown to reduce the
vth. Recently, there has been
ı either arctic fish or winter
n uniformly small ice crystals
orb firmly onto the ice crystal
venting formation of larger ice
ten used to inhibit recrystal-
e, during storage of ice cream
these components are widely
redients affect ice crystalliza-

Emulsion

ules that are adequately stabi-
problem with homogenization,

the fat globules in ice cream mix remain suspended indefinitely (or at least as long as needed). Fat globules in ice cream mix are in a partially solidified state based on the broad range of triacylglycerol molecules that make up milk fat. That is, the milk fat triacylglycerols with high melting points are crystalline in ice cream mix while those with low melting points are in liquid form. It is during cooling after pasteurization and then aging of the mix that most of the fat crystallization takes places. Typically, the milk fat in ice cream mix has fully crystallized after 4–5 hours of aging (Adleman and Hartel, 2002). Also in the aging step, the proteins that stabilize the fat globules are replaced by the emulsifiers present in the mix. This exchange at the surface of the fat globule decreases the interfacial tension and decreases the stability of the globules, rendering them prone to destabilization during shearing in the scraped-surface freezer.

The decreased interfacial tension at the surface of the globules and the shearing action during freezing result in destabilization of the emulsion and formation of clusters or aggregates of fat globules. Because the globules are partially crystalline (and are continuing to crystallize as the temperature is lowered during freezing), they coalesce only partially forming clusters of fat globules as shown schematically in Figure 7.3 and by transmission electron microscopy in Figure 7.6 (also see Figure 2.3). These partially-coalesced fat globules migrate towards the air cell interface and provide structure to the unfrozen phase of the mix as they help to stabilize the air cells being

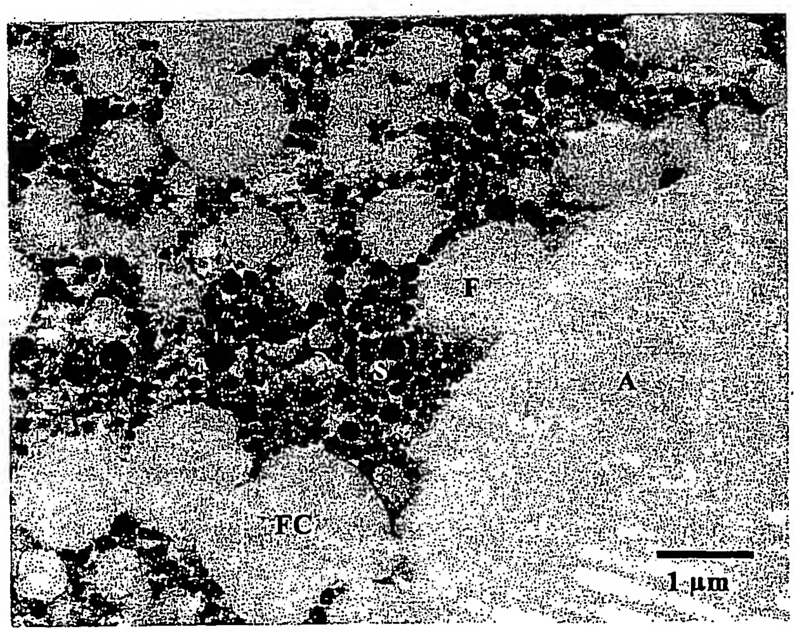


Figure 7.6. Transmission electron micrograph of ice cream showing air interface (A) with adsorbed fat globules (F) and partially-coalesced fat clusters (FC) extending into the serum phase (S) containing the casein micelles.

incorporated into the ice cream. The distribution of fat globules also has a significant impact on physical properties of the finished product, particularly dryness at extrusion and the rate of melt down during holding at temperatures above the freezing point.

The extent of fat destabilization is dependent on the type and amount of emulsifier used in the mix and the nature of the shearing process during freezing. Typically, greater fat destabilization occurs in continuous freezers than in batch freezers due to the higher shearing action of the scraper blades in the former. The use of polysorbate 80 as an emulsifier leads to greater fat destabilization than does the use of mono and diglycerides due to the greater affect of PS 80 on lowering interfacial tension. The degree of saturation of the fatty acids present in mono and diglycerides also influences the level of fat destabilization with unsaturated fatty acids giving greater destabilization (Barfod et al., 1991). Another factor that influences the extent of fat destabilization is the nature of the fat phase. Fats with higher solid fat content (more crystalline fat) generally cause less fat destabilization than those lower in solid fat (Adleman and Hartel, 2002). Fat destabilization can be influenced by the nature of the milk fat used in manufacture of the mix, or through addition of vegetable fats as allowed in Europe and Australia. See Chapter 2 for further details on fat destabilization and structure formation.

Several methods have been used to measure the extent of fat destabilization. One of the earliest methods involved measuring the difference in absorption of light (by spectroscopy) in diluted mix compared to diluted ice cream (Goff and Jordan, 1989). Dilution of the mix leaves a dispersion of fat globules that absorbs a certain amount of light based on the size and number of fat globules. After freezing, there are fewer individual fat globules and more, larger aggregates. Dilution of ice cream leaves a dispersion of fat aggregates that absorbs light to a different extent than does the initial mix. The difference in absorbance between mix and the melted ice cream can, therefore, be used as a measure of fat destabilization. Extent of destabilization has also been measured as the amount of easily extracted fat since the partially coalesced aggregates are more susceptible to organic solvent extraction than are the individual globules (Barfod et al., 1991). More recently, light scattering techniques have been used to quantify the differences in the fat globule size distribution between mix and finished product and to document the increase in size due to aggregation (Bolliger et al., 2000a).

Under certain conditions in an ice cream freezer, excessive fat destabilization leads to churning of the fat. In this case, the fat globules come together in a sufficiently large mass (>30 μm; Wildmoser and Windhab, 2001) such that butter granules appear as distinct entities. These butter granules detract from the appearance of the finished product (dry product), influence the physical properties (increased stiffness) and affect the sensory aspects of the ice cream, imparting a buttery texture to the product.

Incorporation of Air

At the same time that ice crystals are being formed in the freezer and fat globules are coalescing, air is incorporated and air cells are formed. Although

the specifics of the breakdown of
used, the principles of air incorpor
regardless of the type of freezer. A
depending on the type of freezer a
ken down by the shearing actior
freezers, air is injected in the forr
in batch freezers, air is incorpora
liquid. In both cases, air cells a
dependent on the shearing condit
prior to freezing in a pre-aeration s
improved control of air cell size di

The air cells that form in the dy
in size depending on whether the
uous type freezer. The batch type f
air that is incorporated exists at th
freezer. However, the freezing cyli
pressures up to about 690 kPa (1(
produce about 100% overrun witl
freezer make up 15–20% of the vol
the same air cells constitute ab
pressures equilibrate to atmosph
or 14.7 psi absolute) outside the fr

Studies of air incorporation and
of ice cream have clearly shown th
poration under the conditions fo
whipping of ice cream mix in ice
freezing point of the mix results in
large air cell size (Chang and Ha
sizes depends on the increased v
freezing, a slurry of ice crystals i
continuous (unfrozen) phase. This
and the freeze-concentrated conti
ice cream to increase dramaticall
enhances stabilization of air cells
smaller and smaller sizes.

In finished ice cream, the air cel
to over 100 μm. Figure 7.7 shows t
mercial ice cream. Assuming that i
of 60 μm diameter air cells, the nu
8.3×10^6, and the total surface ar
disagreement exists in the literat
cream. Berger and White (1979), l
estimated a mean size of about 6C
Hartel (2002) compared an optic
method for measuring air cell siz
diameter of about 20 μm.

As mentioned above, the air cell
coalesced fat globules that prefer

ɔn of fat globules also has a
ïnished product, particularly
. during holding at tempera-

on the type and amount of
hearing process during freez-
ı continuous freezers than in
of the scraper blades in the
ɜr leads to greater fat desta-
ides due to the greater affect
ree of saturation of the fatty
ınces the level of fat destabi-
ater destabilization (Barfod
:tent of fat destabilization is
fat content (more crystalline
ın those lower in solid fat
ı can be influenced by the
mix, or through addition of
ı. See Chapter 2 for further
:ion.
ıe extent of fat destabiliza-
ng the difference in absorp-
ıpared to diluted ice cream
: a dispersion of fat globules
the size and number of fat
ıal fat globules and more,
lispersion of fat aggregates
the initial mix. The differ-
ce cream can, therefore, be
of destabilization has also
fat since the partially coa-
solvent extraction than are
e recently, light scattering
ıces in the fat globule size
l to document the increase

:, excessive fat destabiliza-
t globules come together in
Windhab, 2001) such that
ıtter granules detract from
ct), influence the physical
:y aspects of the ice cream,

ned in the freezer and fat
:ells are formed. Although

the specifics of the breakdown of air cells depend on the type of freezer being used, the principles of air incorporation during freezing are generally the same regardless of the type of freezer. Air cells start out as large entities, with size depending on the type of freezer and air incorporation technique, and are broken down by the shearing action during freezing. In continuous ice cream freezers, air is injected in the form of small bubbles under pressure, whereas in batch freezers, air is incorporated through the folding and mixing of the liquid. In both cases, air cells are reduced in size as freezing progresses, dependent on the shearing conditions in the freezer. Air can be incorporated prior to freezing in a pre-aeration step (under high shear conditions) to provide improved control of air cell size distribution.

The air cells that form in the dynamic freezing step may differ significantly in size depending on whether the product is being made in a batch or continuous type freezer. The batch type freezer operates at atmospheric pressure, so air that is incorporated exists at the same pressure both inside and outside the freezer. However, the freezing cylinder of the continuous freezer is held under pressures up to about 690 kPa (100 psi). Pressures of about 520 kPa (75 psi) produce about 100% overrun with the normal mix, and the air cells in the freezer make up 15–20% of the volume of the mix. However, due to expansion, the same air cells constitute about 50% of the product volume when the pressures equilibrate to atmospheric pressure (1 atmosphere is 101.4 kPa or 14.7 psi absolute) outside the freezer.

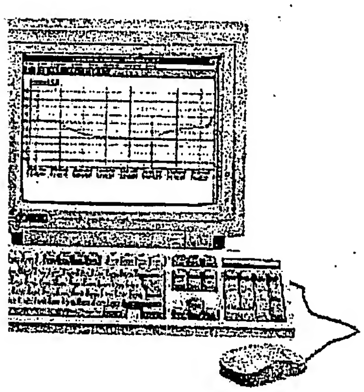
Studies of air incorporation and air cell size reduction during manufacture of ice cream have clearly shown that formation of ice is necessary for air incorporation under the conditions found in typical ice cream freezers. That is, whipping of ice cream mix in ice cream freezers at temperatures above the freezing point of the mix results in limited overrun development and relatively large air cell size (Chang and Hartel, 2002). The capacity to reduce air cell sizes depends on the increased viscosity that comes from freezing. During freezing, a slurry of ice crystals is being formed in an increasingly viscous continuous (unfrozen) phase. This combination of the dispersed (ice crystals) and the freeze-concentrated continuous phases causes the viscosity of the ice cream to increase dramatically during freezing. This increased viscosity enhances stabilization of air cells and allows air cells to be broken down to smaller and smaller sizes.

In finished ice cream, the air cells are found in a range of sizes, from a few to over 100 μm. Figure 7.7 shows the air cell size distribution in a typical commercial ice cream. Assuming that ice cream contains 100% overrun in the form of 60 μm diameter air cells, the number of air cells per gram is approximately 8.3×10^6, and the total surface area is approximately 0.1 m^2. However, some disagreement exists in the literature on mean size of air cells found in ice cream. Berger and White (1979), based on optical micrographs of ice cream, estimated a mean size of about 60 μm. However, recent work by Chang and Hartel (2002) compared an optical microscope method with a cryo-SEM method for measuring air cell size distribution and found a mean air cell diameter of about 20 μm.

As mentioned above, the air cells are primarily stabilized by the partially-coalesced fat globules that preferentially migrate to the air cell interface.

e indicating time of production and
trace the product to its origin. All
etained until there is minimal risk
for consumption. Inventory control
on in storage, and date of produc-
require records of composition (by
and overrun. Management must
which the product can be held with-
of quality. This time will vary with
inherently shorter shelf life than
ll be conditions of storage and the
and handling at the final destina-
detect defects of each type of prod-
more, it is important to have
storage time for each product.
cessing, freezing, and storage is
stored ingredients must be moni-
d more readily than in the distri-
trucks and in facilities that do not
temperature monitors that pre-
ended (Figure 9.10). The monitor
ing once a record has been made.
s where the optimal temperature
often place recorders at the front,
designed, constructed, and main-

distribution system should never
retail cabinet. Therefore, truck
prior to loading, and kept cold by



e in sensitive locations. The monitor
ry components. It is queried by a
atures after shipment is completed.

mechanical refrigeration. The refrigeration system must be operated optimally during distribution. Exposure of frozen product to warm temperature during off-loading into store freezers must be limited to a few minutes to avoid heat shock and development of large ice crystals.

Changes that Occur during Shipping and Handling

Once ice cream leaves the storage freezer in the manufacturing plant, it typically goes through a shipping and handling system designed to deliver the product to the consumer with the highest possible quality. Packaged ice cream for consumer sale undergoes a series of transportation and storage events that lead to the consumer's home freezer, with the particular system being dependent on manufacturer, the distance for distribution, and the equipment and facilities available. The ice cream may go through a centralized warehouse for redistribution to the retail outlet, or it may be shipped directly from the manufacturing plant to the retail outlet.

A survey of ice cream manufacturers by Keeney (1992) provides typical time scales for storage at the different points during shipping and handling. Typically, the ice cream spent about 2 weeks in the warehouse freezer in the manufacturing plant (36% of respondents), although the times varied from 1 to over 4 weeks. The ice cream was then shipped to a distribution center where it spent over 4 weeks (64% of respondents) before being shipped to the retail outlet. Ice cream was typically purchased within 2 weeks (68% of respondents) of arrival at the retail outlet and used within 2 weeks by the consumer. Some (21%) of the respondents indicated that the ice cream spent over 4 weeks at the retail outlet prior to consumption. At each point in shipping and handling, temperatures are slightly different and temperature fluctuations may occur. Approximate times, storage temperatures and temperature fluctuations during shipping and handling of ice cream as shown in Table 9.4.

There are numerous potential problems that can arise during shipping and handling, any one of which can seriously detract from product quality. The most important of these potential problems is thermal abuse and its effect on ice crystals. Temperature fluctuations during shipping and handling of ice cream may be associated with (1) changes in temperature of storage as the product moves from point to point in the chain, (2) heat shocks, where product is left at ambient (room) temperatures for extended periods of time, (3) normal

Table 9.4. Approximate Distribution Sequence for Ice Cream[a]

Steps in storage and distribution system	Temperature (°C)	Duration
Storage freezer in manufacturing plant	−22	2 weeks
Vehicle from plant to central warehouse	−19	6 hours
Storage freezer in central warehouse	−24	4 weeks
Vehicle from warehouse to retail outlet	−19	3 hours
Storage in retail outlet (freezer and retail cabinet)	−15.6	1 week
Consumer vehicle from retail outlet to home	21.0	0.5 hour
Consumer home freezer	−12.0	1 week

[a]Adapted from Ben-Yoseph and Hartel (1999) and Keeney (1992).

ICES

Sanitary Standards for Equipment for
23-03. Available at http://www.3-A.org.
ıter simulation of ice recrystallization in
9–331.
ıpment of air cells in a batch ice cream

of air cells in ice cream during harden-

cream by liquid immersion. *Ice Cream*

cream and ice milk. Ph.D. thesis, Univ.

e of temperature on ice recrystallization
ternational Dairy J. 6:1209–1222.
Dairy Engineering, 2nd ed., John Wiley

of recrystallization in ice cream. In
6, D. S. Reid (Ed.), Blackie, London,

en Publ., NY.
of Milk and Milk Products, 3rd ed.
N°300/1995.
e stored? Proceedings of Penn State
Ed.), Pennsylvania State University,

ater economy in your filling operation.

ntal constraints on packaging of dairy
of Dairy Products, 3rd ed. Bulletin of

ensus Statement. Optimal Calcium

10
Soft-Frozen Dairy Desserts

SOFT-SERVE PRODUCTS

Soft-frozen dairy desserts appeal to many consumers because of their creamy and smooth texture. These dessert products are typically frozen on the retail premises from manufactured and distributed mix and are consumed in the soft frozen state soon after being prepared, without hardening, in the form of cones, sundaes, parfaits, banana splits, milkshakes, and related items. Soft-frozen desserts became popular in the 1950's and remain popular with customers of shops focusing on these products and in fast-food style restaurants. Less capital is needed by the retailer to get into the soft-serve ice cream business than to make and sell hard-frozen ice cream. Although vanilla is by far the most common flavor, chocolate, strawberry and other flavors can also be found. Recently there has been increasing interest in coffee-based desserts. Opportunities to add flavored syrups and/or mix-ins have greatly increased the consumer's options for soft-serve products. Soft frozen desserts include ice cream, light or lowfat ice cream, ice milk, frozen custard and frozen yogurt.

SOFT-SERVE MIX COMPOSITION

The way soft-serve products are marketed makes it possible to use formulas that differ considerably from formulas for hard-frozen products. Although some ice creams made in soft-serve shops are hardened after being packaged or are formed into novelties, the principal forms in which they are marketed are as soft-frozen products and shakes.

Soft-serve mixes are unique in composition, stability and whippability. A fat content below about 4% increases risks of having a coarse or icy texture and weak body. A fat content above about 12% is associated with significant risk of churning in the freezer and a greasy mouth coating. Lower fat versions are common. The NMS content varies inversely with fat content and may be as high as 14% for a lowfat formula. Generally, while the fat content is kept lower, the NMS content is higher than for hard-frozen products. Lactose crystallization is not a problem in these products, as they are consumed immediately after freezing. The sugar content ranges from 13 to 15%, which is

somewhat lower than for regular ice cream. Sweetener content has to be balanced with the amount of lactose from the NMS to provide the right consistency (freezing point and ice phase volume are affected) at the appropriate draw temperature, so higher NMS contents suggest lower sugar contents. Corn syrup solids are often used, but overuse can lead to an enhanced sensation of gumminess.

Stabilizers and emulsifiers are used in amounts ranging from 0.2 to 0.3% and from 0.1–0.2%, respectively. Stabilizers are required for viscosity enhancement and mouthfeel, but their function in ice recrystallization is not needed since hardening and storage are not involved. Dryness and shape retention, however, are a big concern in soft-serve products, hence the emulsifier content is generally kept high. Whipping is also done under conditions closer to batch than continuous freezing, so emulsifiers are needed to help produce finely distributed air cells. All of these properties contribute to the smoothness of the final product. Calcium sulfate may be used at about a rate of 0.1% to enhance dryness and stiffness. Most stabilizer/emulsifier suppliers have blends specially prepared for soft-frozen products. Some typical formulas for soft-serve products are shown in Table 10.1.

Typical formulas for full fat ice cream used as soft-serve contain 2–3% less sugar than do formulas for regular ice cream. Frozen custards may be of moderate or high fat content and are required to contain 1.4% egg yolk solids for the plain flavors and 1.12% for bulky flavored products. Typical formulas for soft-serve frozen custard have approximately the following composition: Fat—5–10%, NMS—11%, sugar—14%, egg yolk solids—1.4%, and stabilizer/emulsifier—0.4%. Total solids generally range from 32 to 37%.

Soft products are usually drawn from the freezer at −6.7 to −7.8°C (18 to 20°F). Fat separation, increase in sizes of ice crystals, and lactose crystallization are likely defects that result from cycling of the freezer to maintain temperature during extended holding times.

Overrun of soft-serve products ranges from 30 to 60%, depending on the TS content. The higher the TS content, the higher the overrun may be while maintaining desirable body and texture characteristics. Suggested limits for overrun and serving temperature vary among products (Table 10.2).

Consumption of soft serve frozen dairy desserts in the U.S. approximates 6 L/yr (6.3 qt). This total is comprised of lowfat and nonfat ice creams—70%, regular ice cream—19%, frozen yogurt—10%, and sherbet—1%.

Table 10.1. Typical Formulas for Soft-Serve Ice Creams

Constituents[a]	%						
Milk fat	3.0	3.0	4.0	5.0	6.0	6.0	10.0
NMS	14.0	14.0	14.0	13.0	12.5	13.0	11.0
Sugar	10.0	14.0	11.0	12.0	12.0	13.0	12.0
CSS	4.0	—	4.5	4.0	4.0	—	3.0
S/E	0.5	0.5	0.5	0.4	0.4	0.5	0.4
TS	31.5	31.5	34.0	34.4	34.9	32.5	36.4

[a]NMS—nonfat milk solids; CSS—corn syrup solids; S/E—stabilizer plus emulsifier; TS—total solids.

Table 10.2. Suggested L

Products	Ove
Soft-serve	30-
Milk shake	40-
Sherbet	30-
Italian ice	30-

(Source: The Latest Scoop, I
Department of Agriculture st
1989 and discontinued record
for milk fat) type products in
these products in the current
the market, with periods in b
market share.

With the change in defin
the Standard of Identity for ic
introduction of new low fat ice
minimal effect on formulations
fat versions anyway. Generally
uct name nor sold with nutritic
inform the buyer of the calori
sumers most likely make choic
ucts on bases other than f
are required on each package t
significantly.

Milk shake mixes fall outsi
are not defined in regulations
they should contain at least 3.2
Canada, milk shake mixes must
Compared with ice cream the
sugar. The TS content is char
milk shakes overrun should be
desirable to use emulsifier in
follow:

Constituents
Fat
NMS
Sugar
Corn syrup solids
Stabilizer
TS

Malted milk formulas are
sugar than milk shake formulas

ıg the nitrogen in the sample.
f 6.38 to calculate the protein
trumentally by infrared light

ice cream are weighed into a
on a steam bath and then in
ith its dry contents is weighed
The method of the IDF (1972)
for the weighed sample to be
d with dried sand in the pan.
. subjected to 102°C for 2 hr

regulatory agencies because
ır, control agencies have the
airy ingredient utilization to
met the ice cream standard.
ıstrumental methods. In milk
ncentration of lactose can be
recipitation and filtration fol-
arized light, which is propor-
netric method cannot be used
e of the presence of significant
neter wavelength of infrared
that are abundant in lactose,
instrumental method of ana-
h pressure liquid chromatog-
concentration of lactose.
a bomb calorimeter to deter-
e. However, caloric content is
2). Minerals are quantified
ectroscopy. Biometric or spec-
tamins.
ermine the content of various
oducts of degradation of the
atty acids might be done if a
rancidity); or a test for alde-
ncidity. Tests to quantify cer-
ritional labeling if a reliable
ient(s).

IES

ıe

sserts that concerns regula-
ct, and this is affected by the
is whipped into a mix during
overrun has been obtained.

Thus, a mix weighing 1.1 kg/liter would produce 2 liters of ice cream weighing 0.55 kg each. One gallon of mix weighing 9.2 lb produces 2 gallon of ice cream weighing 4.6 lb each. Ice creams are classified by industry as super premium, premium, regular or trade brand, and economy. The overrun of super premium ice creams may be as low as 20%, whereas that of economy ice creams is usually at the maximum limit.

Overrun can be calculated (see Chapter 5 for details and examples) for individual containers by determining the portion of mix displaced by air in the specific package as follows:

$$\% \text{ package overrun} = [(\text{mix weight} - \text{product weight})/\text{product weight}] \times 100$$

"Plant (manufacturing) overrun" is an expression of the increase in volume of an entire lot of ice cream mix. For example, if 10,000 liters of mix are frozen into 18,000 liters of ice cream, the overrun is 80%.

$$\% \text{ Plant overrun} = [(\text{volume of product} - \text{volume of mix})/\text{volume of mix}] \times 100$$

Determining the volume of frozen novelties is often difficult. Tests usually involve immersion of the frozen novelty into a cooled liquid, such as glycol, and determining the amount of liquid displaced (Dubey and White, 1997). Handbook 133 of the National Bureau of Standards provides the procedure (1981). Further details on calculations of overrun are given in Chapter 5.

Hardness

Hardness of the product at the temperature at which it has the optimum consistency for dipping is an important consideration. Hardness is affected by several factors: principally melting point, total solids, overrun and amount and type of stabilizer. However, choice of the amount and type of stabilizer depends on factors other than hardness, and especially on the need to modify the properties of ice and the aqueous phase to increase shelf life. When an ice cream store keeps several containers of product in a single cabinet from which each is to be dipped or scooped, only one temperature setting is available. Therefore, it is desirable to have the melting points and overruns of all flavors of ice cream nearly the same. This is not easy to accomplish because formulae involve several variables that affect the concentration of dissolved substances and, therefore, the melting point. Freezing and melting points decrease as the concentration of water-soluble substances increase. The ice cream formulator must carefully choose amounts of monosaccharide sweeteners, such as glucose, to use. On an equal weight basis, glucose lowers the freezing point twice as much as does the disaccharide sucrose while providing only three-fourths as much sweetness.

Hardness can be determined with a puncture probe placed on a texture analyzer. The resistance to penetration of the probe is measured repeatedly in ice cream that is adjusted to a precise temperature (Goff et al., 1995a). Comparisons to a reference curve enable decisions to be made regarding needs for changes in formulation.